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J6674(C)
Y2-R567-EDG

STABLE SKIN CONDITIONING COMPOSITIONS CONTAINING RETINOID BOOSTERS

This application claims priority under 35 U.S.C. §119(e) from U.S. provisional application serial number 60/258,455, filed December 28, 2000.

FIELD OF THE INVENTION

The present invention relates to stable skin conditioning compositions containing certain compounds which boost the effects of retinoids.

BACKGROUND OF THE INVENTION

Natural or synthetic vitamin A derivatives have been used extensively as skin repair or renewal agents in the treatment of a variety of skin disorders. Retinoic acid has been employed to treat a variety of skin conditions, e.g., acne, wrinkles, psoriasis, age spots and discoloration. *See, e.g.,* Vahlquist, A. et al., "Isotretinoin Treatment of Severe Acne Affects the Endogenous Concentration of Vitamin A in Sebaceous Glands", *J. Invest. Dermatol.*, Vol. 94, Holland D.B. and Cunliffe, W.J. (1990), pp. 496-498; Ellis, C.N. et al., "Pharmacology of Retinols in Skin," *Basel, Karger*, Vol. 3, (1989), pp. 249-252; Lowe, N.J. et al., "Pharmacology of Retinols in Skin," Vol. 3 (1989), pp. 240-248; and PCT Patent Application No. WO 93/19743.

It is believed that the use of retinol or short chain esters of retinol would be preferred over retinoic acid. Retinol is an endogenous compound which occurs naturally in the human body and is essential for normal epithelial cell differentiation. Short chain esters of retinol hydrolyze in-vivo to produce retinol. Retinol and retinyl

esters are considered to be safer than retinoic acid. However, retinol and retinyl esters are more unstable than retinoic acid. See Idson, "Vitamins and the Skin," *Cosmetics & Toiletties,* Vol. 108, December 1993, pp. 79-94, Allured Publishing Corp. (1993); Hoffman-La Roche Inc., Data Sheet "Vitamin A--The 'Normalizer,'" Roche Vitamins & Fine Chemicals; Hoffman-La Roche Inc., Product Data "Vitamin A Alcohol Blend." Specifically, they rapidly degrade in the presence of water.

Several methods of stabilizing certain types of retinoids in formulations have been disclosed. For example, U.S. Patent No. 6,113,928 issued to Nogueira et al., (hereinafter "Nogueira") discloses stable non-alcoholic cosmetic compositions containing 13-trans retinal which is an oil-in-water emulsion in which the fatty phase constituents have a peroxide number no greater than about 5, and in which the fatty phase includes 10-15% by weight of capric/caprylic triglycerides and 0.02-0.5% by weight of the antioxidant BHT, and method of making the same.

U.S. Patent No. 5,744,148 issued to Habif et al. (hereinafter "Habif") discloses oil-in-water emulsions containing an unstable retinoid in an oil phase. The retinoid is stabilized in the inventive emulsions, despite the presence of about 50% to about 98% of an aqueous phase by employing a specific oil phase to form oil droplets containing a solubilized unstable retinoid and employing selected combinations of solid components to form a barrier layer of specifically sized crystals for the oil droplets. Crystal sizing and barrier layer formation, however, are difficult to implement.

U.S. Patent No. 4,826,828 issued to Wilmott et al. (hereinafter "Wilmott") discloses the use of volatile silicones and ethanol for the preparation of compositions containing retinol. The preparations can be diluted before application

by formation of a water/oil emulsion. However, the formulation does not give satisfactory storage results and water/oil emulsions are poorly suited for topical application.

None of the art discussed hereinabove discloses an efficient method of stabilizing retinoids in an oil-in-water emulsion through control of the emulsion characteristics while also providing the dual benefit of potentiating the action of the retinoids.

There is, therefore, a continuing need for improvements in stability of retinols in skin care compositions while increasing the effectiveness of retinol.

SUMMARY OF THE INVENTION

The present invention relates to an oil-in-water skin conditioning emulsion composition comprising:

(a) about 0.001 wt. % to about 10 wt. % of a booster compound;

(b) about 0.001 wt. % to about 10 wt. % of a retinoid; and

(c) a cosmetically acceptable vehicle, wherein each constituent of the oil phase of the oil-in water emulsion has a peroxide value of less than or equal to about 12.

DETAILED DESCRIPTION OF THE INVENTION

Except in the operating and comparative examples, or where otherwise explicitly indicated, all numbers in this description indicating amounts of material or conditions of reaction, physical properties of materials and/or use are to be

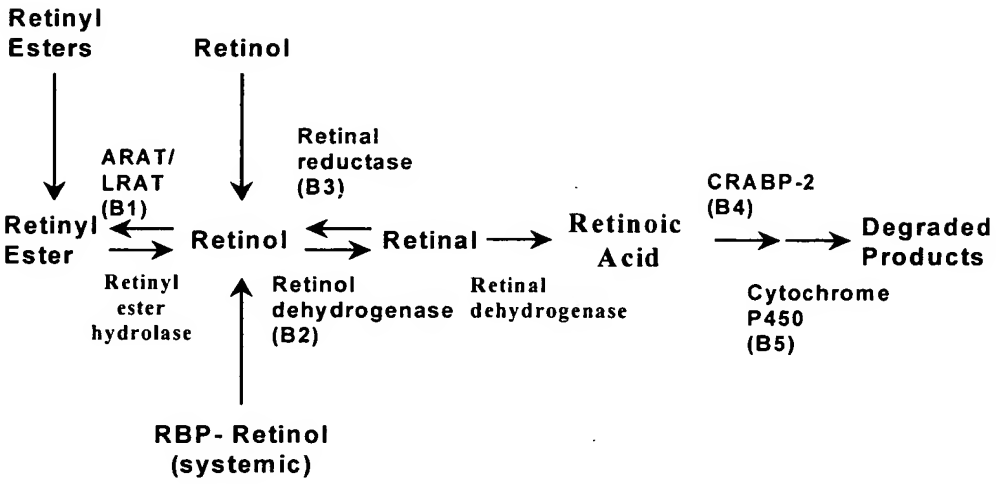
understood as modified by the word "about." All amounts are by weight of the oil-in-water emulsion, unless otherwise specified.

The term "skin" as used herein includes the skin on the face, neck, chest, back, arms, hands, legs, and scalp.

All amounts are by weight of an oil-in-water emulsion, unless otherwise indicated.

The present invention is based, in part, on the discovery that certain compounds inhibit ARAT/LRAT, retinal reductase, CRABPII and retinoic acid oxidation (the latter catalyzed by cytochrome P450 systems), whereas certain other compounds enhance retinol dehydrogenase. It is believed that retinol esters and retinol are enzymatically converted in the skin into retinoic acid according to the mechanism of Chart 1.

Retinol metabolism in the epidermis: enzyme names



ARAT/LRAT = Acyl Coenzyme A (CoA): Retinol Acyl Transferase/Lecithin:Retinol Acyl Transferase

CRABPII = Cellular Retinoic Acid Binding Protein II

The compounds are collectively termed herein as "boosters" and are coded as groups B1 through B5 on Chart 1. The boosters, alone or in combination with each other, potentiate the action of retinoid by increasing the amount of retinol available for conversion to retinoic acid and inhibiting the degradation of retinoic acid. The boosters act in conjunction with a retinoid (e.g. retinol, retinyl ester, retinal, retinoic acid), the latter being present endogenously in the skin. The present inventive

compositions include a retinoid in the composition, co-present with a booster, to optimize performance.

The present invention includes, in part, a skin conditioning composition containing about 0.0001% to about 50%, preferably 0.001% to 10%, most preferably 0.001% to 5% by weight of the composition of at least one booster compound, wherein the compound or compounds, at a combined concentration of 10mM inhibit transglutaminase in an in vitro transglutaminase assay to more than 50%. The inventive composition also includes a retinoid in an oil in water emulsion with an oil phase having a peroxide value (POV) of less than 12 and a cosmetically acceptable vehicle.

The boosters included in the inventive compositions are selected from the group consisting of:

(a) Two boosters, wherein both are selected from the same group consisting of B2; B3; B4;

(b) binary combinations of boosters selected from the group consisting of

B1/B2; B1/B3; B1/B4; B1/B5; B2/B3, B2/B4; B2/B5, B3/B4; B3/B5; B4/B5

(c) ternary combinations of boosters selected from the group consisting of

B1/B2/B3; B1/B2/B4; B1/B2/B5; B1/B3/B4; B1/B3/B5; B1/B4/B5;B2/B3/B4; B2/B3/B5; B2/B4/B5; B3/B4/B5

(d) quaternary combinations of boosters selected from the group consisting of

B1/B2/B3/B4; B1/B2/B3/B5; B1/B2/B4/B5; B1/B3/B4/B5; B2/B3/B4/B5; and

(e) a combination of five groups of boosters: B1/B2/B3/B4/B5.

The preferred compositions include at least one booster from one of the groups (i.e., (b) through (e) above).

The compounds included in the present invention as boosters are first selected based on the ability of such compounds to pass, at a certain concentration listed in Table A, an in-vitro Microsomal Assay for a specific enzyme as described below under sections 2.1 through 2.7. The compound (alone or in combination with another booster) is then subjected to an in vitro transglutaminase assay described below, at an individual or combined concentration of 10 mM. If such combination inhibits transglutaminase to more than 50%, than it is suitable for use in the present invention. If a booster was tested individually, and passes the transglutaminase assay, then it may be combined with another booster or combination that passes the transglutaminase assay.

Preferred compositions according to the present invention contain at least one booster or combinations of booster which at an individual concentration of 10 mM inhibit transglutaminase to more than 50%.

The term "conditioning" as used herein means prevention and treatment of dry skin, acne, photodamaged skin, appearance of wrinkles, age spots, aged skin, increasing stratum corneum flexibility, lightening skin color, controlling sebum excretion and generally increasing the quality of skin. The composition may be used to improve skin desquamation and epidermal differentiation.

A booster is a compound which passes an in vitro Microsomal Assay described below in sections 2.1 through 2.7. A compound suitable for use in the present invention inhibits or enhances at a concentration listed in Table A, an enzyme, to at least a broad % listed in Table A.

TABLE A

Booster Test Concentrations and % Inhibition/Increase

ARAT / LRAT Assay *(To identify B1 boosters)*

Invention	Compound Concentration	% Inhibition
Broad	100 *M	> 10%
Preferred	100 *M	> 25%
Most Preferred	100 *M	> 40%
Optimum	100 *M	> 50%

Retinol Dehydrogenase Assay *(To identify B2 boosters)*

Invention	Compound Concentration	% Increase
Broad	100 *M	> 10%
Preferred	100 *M	> 15%
Most Preferred	100 *M	> 20%
Optimum	100 *M	> 25%

Retinal Reductase Assay *(To identify B3 boosters)*

Invention	Compound Concentration	% Inhibition
Broad	100 *M	> 5%
Preferred	100 *M	> 10%
Most Preferred	100 *M	> 20%
Optimum	100 *M	> 35%

CRABPII Antagonist Assay *(To identify B4 boosters)*

Invention	Compound : RA Ratio	% Inhibition
Broad	7000 : 1	> 25%
Preferred	7000 : 1	> 50%
Most Preferred	70 : 1	> 25%
Optimum	70 : 1	> 50%

Retinoic Acid Oxidation Assay *(To identify B5 boosters)*

Invention	Compound Concentration	% Inhibition
Broad	100 *M	> 25%
Preferred	100 *M	> 45%
Most Preferred	100 *M	> 70%
Optimum	100 *M	> 80%

The in vitro Microsomal Assays employed for determining the suitability of the inclusion of the compound in the inventive compositions are as follows:

1. Materials

All-trans-retinol, all-trans-retinoic acid, palmitoyl-CoA, dilauroyl phosphatidyl choline, NAD, and NADPH were purchased from Sigma Chemical Company. Stock solutions of retinoids for the microsomal assays were made up in HPLC grade acetonitrile. All retinoid standard stock solutions for HPLC analysis were prepared in ethanol, stored under atmosphere of N_2 at -70°C and maintained on ice under amber lighting when out of storage. Other chemicals and the inhibitors were commercially available from cosmetic material suppliers or chemical companies such as Aldrich or International Flavors and Fragrances.

2. Methods

2.1 Isolation of RPE microsomes (modified from J. C. Saari & D. L. Bredberg, "CoA and Non-CoA Dependent Retinol Esterification in Retinal Pigment Epithelium", *J. Bill. Chem.* 263, 8084-8090 (1988))

50 frozen hemisected bovine eyecups, with the retina and aqueous humor removed were obtained from W. L. Lawson Co., Lincoln, NE, USA. The eyes were thawed overnight and the colored iridescent membrane was removed by peeling with forceps. Each eyecup was washed with 2x 0.5mL cold buffer (0.1M PO_4 / 1mM DTT / 0.25M sucrose, pH 7) by rubbing the darkly pigmented cells with an artist's brush or a rubber policeman. The cell suspension was added to the iridescent membranes and the suspension was stirred for several minutes in a beaker with a Teflon stir bar. The suspension was filtered through a coarse filter (Spectra / Por 925μ pore size polyethylene mesh) to remove large particles, and the resulting darkly colored suspension was homogenized using a Glas-Col with a motor driven Teflon homogenizer. The cell homogenate was centrifuged for 30 min. at 20,000g (Sorvaal model RC-5B centrifuge with an SS34 rotor in 2.5x10cm tubes at 14,000 RPM). The resulting supernatant was subjected to further centrifugation for 60 min. at 150,000g (Beckman model L80 Ultracentrifuge with an SW50.1 rotor in 13x51mm tubes at 40,000 RPM). The resulting pellets were dispersed into ~5mL 0.1M PO_4 / 5mM DTT, pH 7 buffer using a Heat Systems Ultrasonics, Inc. model W185D Sonifier Cell Disruptor, and the resulting microsomal dispersion was aliquoted into small tubes and stored at -70°C. The protein concentrations of the microsomes were determined using the BioRad Dye binding assay, using BSA as a standard.

2.2 Isolation of rat liver microsomes (Martini & M. Murray, "Participation of P450 3A Enzymes in Rat Hepatic Microsomal Retinoic Acid 4-Hydroxylation", Archives Biochem. Biophys. 303, 57-66 (1993)).

Approximately 6 grams of frozen rat liver (obtained from Harlan Sprague Dawley rats from Accurate Chemical and Scientific Corp.) were homogenized in 3 volumes of 0.1M tris / 0.1M KCl / 1mM EDTA / 0.25M sucrose, pH 7.4 buffer using a Brinkmann Polytron. The resulting tissue suspension was further homogenized in the motor driven Teflon homogenizer described above. The resulting homogenate was successively centrifuged for 30 min. at 10,000g, 30 min. at 20,000g, and 15 min. at 30,000g, and the resulting supernatant was ultracentrifuged for 80 min. at 105,000g. The pellet was sonicated in ~5mL of 0.1M PO_4 / 0.1mM EDTA / 5mM $MgCl_2$, pH 7.4 buffer as described above and stored as aliquots at -70°C. Protein concentrations were determined as described above.

2.3 Assay for ARAT and LRAT activity (To identify B1)

The procedure below is a modification of a method described in J. C. Saari & D. L. Bredberg, "ARAT & LRAT Activities of Bovine Retinal Pigment Epithelial Microsomes", Methods Enzymol. 190, 156-163 (1990). The following buffer was prepared and stored at 4°C: 0.1M PO4 / 5mM dithiothreitol, pH 7.0 (PO_4 / DTT). On the day of the assay, add 2mg BSA per mL of buffer to give a PO_4 / DTT / BSA working buffer. 1mM retinol substrate was prepared in acetonitrile and stored in amber bottles under nitrogen gas at -20°C. Solutions of 4mM Palmitoyl-CoA in working buffer (stored in aliquots) and 4mM dilauroyl phosphatidyl choline in ethanol were prepared and stored at -20°C. Inhibitors were prepared as 10mM stock solutions in water, ethanol, acetonitrile or DMSO. The quench solution was prepared

using pure ethanol containing 50µg/mL butylated hydroxytoluene (BHT), and a hexane solution containing 50µg/mL BHT was used for the extractions.

To a 2 dram glass vial, add the following in order: PO_4 / DTT / BSA buffer to give a total volume of 500µL, 5µL acyl donor (4mM palmitoyl-CoA and/or dilauroyl phosphatidyl choline), 5µL inhibitor or solvent blank (10mM stock or further dilutions) followed by approximately 15µg of RPE microsomal protein (approximately 15µL of a ~1mg/mL microsomal protein aliquot). Incubate for 5 min. at 37°C to equilibrate the reaction temperature and then add 5µL 1mM retinol. Cap the vials, vortex for 5 seconds and incubate for 30-90 minutes at 37°C. Quench the reaction by adding 0.5mL ethanol / BHT. Extract the retinoids by adding 3mL hexane / BHT, vortex the tubes for several seconds several times and centrifuge the tubes at low speed for 5 min. to quickly separate the layers. Remove the upper hexane layer into a clean vial, and re-extract the aqueous layer with another 3mL hexane / BHT, as described above. Combine the hexane layers and evaporate the hexane by drying at 37°C under a stream of nitrogen gas on a heated aluminum block. Store the dried residue at -20°C until HPLC analysis. Quantitate the amount of retinyl palmitate and retinyl laurate for ARAT and LRAT activity, respectively, by integration of the HPLC signal as described below.

Note that the incubation solution contains 40µM acyl donor, 100µM or less inhibitor, 10µM retinol, approximately 30µg/mL microsomal protein, and nearly 0.1M PO_4, pH 7 / 5mM DTT / 2mg/mL BSA. All steps subsequent to the addition of retinol were done in the dark or under amber lights.

2.4 Assay for Retinol Dehydrogenase Activity (To identify B2)

The following stock solutions were prepared:

50mM KH_2PO_4, pH 7.4 buffer, sterile filtered.

10mM all trans Retinol (Sigma R7632) in DMSO.

200mM Nicotinamide adenine dinucleotide phosphate, sodium salt (NADP) (Sigma N0505) in sterile water.

40mM test compound in appropriate solvent (water, buffer, ethanol, chloroform or DMSO).

1:10 dilution of rat liver Microsomes in 50mM KH_2PO_4, pH 7.4 buffer (4ug/ul).

In a two-dram glass vial with screw cap, add the following in order:

Buffer to give a final volume of 400µl

25µl diluted Microsomes (final = 100µg) – use boiled Microsomes for controls and regular Microsomes for test samples.

4µl of 200mM NADP (final = 2mM)

1µl of 40mM test compound (final = 100µM)

8µl of 10mM retinol (final = 200µM)

Incubate vials in a 37°C shaking water bath for 45 minutes. Add 500µl ice-cold ethanol to each vial to quench the reaction. Extract the retinoids twice with ice cold hexane (2.7ml per extraction). Retinyl acetate (5µl of a 900µM stock) is added to each vial during the first extraction as a means of monitoring the extraction efficiency in each sample. Samples were vortexed for ten seconds before gently centrifuging for five minutes at 1000rpm, 5°C in a Beckman GS-6R centrifuge. The top hexane layer containing the retinoids is removed from the aqueous layer after each extraction to a clean two-dram vial. Evaporate off the hexane under a gentle stream of nitrogen gas. Store the dried residue at –20°C until HPLC analysis.

2.5 Assay for Retinal Reductase Activity (To identify B3)

All stock solution were prepared as above with the following substitutions:

10mM all trans Retinaldehyde (Sigma R2500) in DMSO – instead of retinol.

200mM, Nicotinamide adenine dinucleotide phosphate, reduced form, tetrasodium salt (NADPH) (Sigma N7505) in sterile water – instead of NADP.

In a two-dram glass vial with screw cap, add the following in order:

Buffer to give a final volume of 400µl

25µl diluted Microsomes (final = 100µg) – use boiled Microsomes for controls and regular Microsomes for test samples.

4µl of 200mM NADPH (final = 2mM)

1µl of 40mM test compound (final = 100µM)

3µl of 10mM retinaldehyde (final = 75µM)

Follow the same incubation and extraction procedure as detailed above.

2.6 Assay for CRABPII antagonists (To identify B4)

2.6.1. Synthesis of CRABPII

a. System of expression

The gene CRABPII was cloned in pET 29a-c(+) plasmid (Novagen). The cloned gene was under control of strong bacteriophage T7 transcription and translation signals. The source of T7 polymerase was provided by the host cell E.coli BLR(DE3)pLysS (Novagen). The latter has a chromosomal copy of T7 polymerase under lacUV5 control, induced by the presence of IPTG. The plasmid was transferred into E. coli BLR(DE3)pLysS cells by transformation according to the manufacturer protocol (Novagen).

b. Induction

An overnight culture of the transformed cells was diluted 1:100 into 2xYT containing 50 µg/mL kanamycin and 25µg/mL chloramphenicol. The cells grew while shaking at 37°C until the OD at 600 nm reached 0.6-0.8. Then IPTG was added to a final concentration of 1mM and the culture was incubated for an additional two hours. The cells were harvested by centrifugation at 5000g for 10 minutes at room temperature. The pellet was stored at –20°C.

2.6.2. Purification

Purification was performed according to the method described in Norris, A.W. and Li, E., "Generation and characterization of cellular retinoic acid-binding proteins from Escherichia coli expression systems", *Methods Enzymol.* 282, 3-13, 1997.

a. Lysis

The frozen pellet was thawed at RT and resuspended in 1-2 pellet volumes of freshly prepared lysis buffer (50 mM Tris-Hcl, pH 8, 10%(w/v) sucrose, 1 mM EDTA, 0.05%(w/v) sodium azide, 0.5 mM DTT, 10 mM $MnCl_2$, 2.5 mM phenylmethylsulfonyl fluoride, 2.5 mM benzamidine, 6µg/mL DNase). The lysate was incubated for 30 min at room temperature. Further lysis was accomplished by sonication (six 30-sec bursts at 10,000 psi alternated with five 30-sec delay on ice). The insoluble fraction of the lysate was removed by centrifugation at 15000 rpm 1 hour at 4°C and the supernatant is stored at –20°C.

b. Gel filtration on Sephacryl S300

The supernatant from step a. was loaded onto a 2.5x100 cm column of sephacryl S-300 (Pharmacia) at room temperature. The elution buffer was

20 mM Tris-HCl, pH 8, 0.5mM DTT, 0.05% sodium azide (buffer A). The flow rate was 2mL/min. Collected 2-mL fractions were checked for ultraviolet absorbance at 280 nm. The fractions representing the peaks were examined by SDS-page for the presence of CRABPII .

c. Anion-exchange chromatography

2 mL of gel filtration fractions containing CRABPII were loaded onto a quaternary amine anion-exchange column FPLC (Fast Protein Liquid Chromatography) type monoQ (Pharmacia). CRABPII was eluted using a gradient buffer from 100% buffer A to 30% buffer B (100 % buffer B = buffer A + 250 mM NaCl) over a 20-min period at room temperature.1 mL-fractions were collected every minute. Once more, the presence of CRABPII was checked by SDS page. CRABPII was stored at 4°C before freeze-drying using a Micromodulyo 1.5K with vial platform attachment (Edwards High Vacuum International). The desiccated samples were stored at room temperature until their use in the binding assay.

d. Detection of the presence of CRABPII

The expression and purification of CRABPII was validated using denaturing SDS-polyacrylamide gel electrophoresis (SDS-PAGE) analysis on a 7-15% polyacrylamide gel (Biorad). 10 µL samples were mixed with 10 µL of 2X loading buffer (100 mM Tris-HCl pH6.8, 4% SDS, 0.2% BPB, 20% glycerol, 1mM DTT) and denatured by heating (2 min at 80°C). The samples were loaded onto the gel that was immersed in a 1X Tris-glycine buffer (Biorad) and a constant current (25 mA) was applied for 1 hour at room temperature. After Coomassie blue staining, the protein was identified according to its

molecular weight as determinated with the Benchmark prestained protein ladder (Gibco BRL).

A western blot was used to confirm the presence of CRABPII. The proteins separated on the SDS-PAGE were transferred on an Immobilon-P transfer membrane (Millipore) using a Biorad cassette. The transfer occurred in 1X Tris-glycine buffer (Biorad) + 10% methanol. An electrical current (60 mA) was applied for 3 hours to allow the protein to migrate through the membrane. Afterwards, the membrane was blocked with 5% dry milk in 1X TBS for one hour at room temperature and probed with primary antibodies to CRABPII (1/1000 dilution of mouse anticlonal 5-CRA-B3) in the same buffer at 4°C overnight. The following day, the membrane was washed with PBS (3 x 5 minutes) and then incubated with 1:2000 dilution of the secondary antibody, peroxidase conjugated anti-mouse antibody (ECLTM, Amersham), for 1 hour at room temperature. The membrane was washed with 1xPBS (3x 5 minutes) and the protein was detected using ECL detection kit according to the manufacturer instruction (Amersham).

The concentration of purified CRABPII was determined using BSA kit (Pierce).

2.6.3. Radioactive Binding assay

220 pmol of CRABPII was incubated in 20 mM Tris-HCl buffer pH 7.4 with 15 pmol of radioactive all trans retinoic acid (NEN) in a total volume of 70µL. For the competitive assay, another ligand in excess (6670:1, 670:1 or 70:1) was added to the mix. The reaction occured for one hour at room temperature in the dark. In order to separate the unbound all-trans retinoic acid from the bound all-trans retinoic acid, a

6kD cut-off minichromatography column (Biorad) was used. The storage buffer was discarded using a Microplex manifold for according to the manufacturer instruction (Pharmacia). The samples were loaded onto the column and the separation occured by gravity over a 30-min period. Retinoic acid ("RA") bound to CRABPII appeared in the filtrate while free RA remained in the column. The radioactivity of the filtrate was measured by scintillation counter.

2.7 Assay for NADPH dependent retinoic acid oxidation (To identify B5)

The procedure below is a modification of a method described in Martini & M. Murray, "Participation of P450 3A Enzymes in Rat Hepatic Microsomal Retinoic Acid 4-Hydroxylation", Archives Biochem. Biophys. 303, 57-66 (1993). Prepare the following assay buffer and store at 4°C: 0.1M PO_4 / 0.1mM EDTA / 5mM $MgCl_2$, pH 7.4. On the day of the assay, prepare a 60mM NADPH solution in buffer. Prepare inhibitor stocks, acidified ethanol / BHT quench solution, and hexane / BHT as described above. A working 1mM retinoic acid solution was prepared by dilution of a 15mM stock (in DMSO) with ethanol.

To a 2 dram vial, add the following in order: assay buffer to give a final volume of 500µL, 20µL 60mM NADPH, 5µL inhibitor or solvent blank, followed by approximately 2mg of rat liver microsomal protein. Incubate for 5 min. at 37°C, then add 5µL working 1mM retinoic acid solution. Continue incubation for 60min. at 37°C - do not cap the vials, since the oxidation process requires molecular O_2 in addition to NADPH. Quench with acidified ethanol / BHT and extract with hexane / BHT as described above. Quantitate the quickly eluting polar retinoic acid metabolites (presumed to be 4-oxo retinoic acid) by integration of the HPLC signal, as described below.

Note that all steps subsequent to the addition of retinoic acid were done in the dark or under amber lights. The final incubation solution contains 2.4mM NADPH, 100μM or less inhibitor, 10μM retinoic acid, approximately 4mg/mL rat liver microsomal protein and nearly 0.1M PO_4 / 0.1mM EDTA / 5mM $MgCl_2$.

HPLC analysis of individual retinoids

Samples for retinoid quantitation by HPLC were prepared by dissolving the residue in each vial with 100μL of methanol. The solution was transferred to a 150μL glass conical tube within a 1mL shell vial, capped tightly, and placed inside a Waters 715 Autosampler. Aliquots of 60μL were injected immediately and analyzed for retinoid content.

The chromatography instrumentation consisted of a Waters 600 gradient controller/pump, a Waters 996 Photodiode Array detector and a Waters 474 Scanning Fluorescence detector. Two HPLC protocols were used for retinoid analysis. For the ARAT and LRAT assay, the separation of retinol and retinol esters was performed with a Waters 3.9x300mm C18 Novapak reverse-phase analytical column and Waters Sentry NovaPak C18 guard column with an 80:20(v/v) methanol / THF isocratic mobile phase adjusted to a flow rate of 1mL/min. for 10 min. The eluate was monitored for absorbance at 325nm and fluorescence at 325ex/480em. A shorter Waters 3.9x150mm C18 Novapak reverse-phase analytical column and Waters Sentry NovaPak C18 guard column were used to separate retinoid acids and alcohols for the retinol and retinoic acid oxidation assays utilizing a modification of a gradient system described by A. B. Barua, "Analysis of Water-Soluble Compounds: Glucuronides", Methods Enzymol. 189, 136-145 (1990). This system consisted of a 20 min. linear gradient from 68:32(v/v)

methanol/ water containing 10mM ammonium acetate to 4:1(v/v) methanol:dichloromethane followed by a 5 min. hold at a flow rate of 1mL/min.. The column eluate was monitored from 300nm to 400nm.

These protocols were selected based on their ability to clearly resolve pertinent retinoid acids, alcohols, aldehydes, and/or esters for each assay and relative quickness of separation. Identification of individual retinoids by HPLC was based on an exact match of the retention time of unknown peaks with that of available authentic retinoid standards and UV spectra analysis (300-400nm) of unknown peaks against available authentic retinoids.

The boosters suitable for further testing in the transglutaminase assay include but are not limited to the boosters listed in Tables B1 through B5 below.

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ARAT/LRAT Inhibitors (B1)

Class	Compound	% Inhibition Overall TG (- ROH/RE)	Overall TG (IC 50)	% Inhibition ARAT (10µm)	% Inhibition ARAT(100µm)	% Inhibition LRAT (10µm)	% Inhibition LRAT (100µm)
Carotenoid	Crocetin		3.75E-05	15%	34%	0	15%
Fatty Acid Amides & Other Surfactants	Acetyl Sphingosine		6.78E-06	19%+/- 12	62% +/- 11	10% +/- 10	50% +/- 18
Fatty Acid Amides & Other Surfactants	C13 Beta-Hydroxy Acid/Amide	17%			28%		25%
Fatty Acid Amides & Other Surfactants	Castor Oil MEA		3.25E-05				
Fatty Acid Amides & Other Surfactants	Cocamidopropyl Betaine				25%		
Fatty Acid Amides & Other Surfactants	Coco Hydroxyethylimidazoline		2.84E-07		68%		68%
Fatty Acid Amides & Other Surfactants	Cocoamide-MEA (or Cocoyl Monoethanolamide)	11%			13%		34%
Fatty Acid Amides & Other Surfactants	Glycerol-PCA-Oleate				41% +/- 6		58% +/- 2
Fatty Acid Amides & Other Surfactants	Hexanoamide				20%		
Fatty Acid Amides & Other Surfactants	Hexanoyl Sphingosine		9.99E-05		28% +/-4		37%
Fatty Acid Amides & Other Surfactants	Hydroxyethyl-2-Hydroxy-C12 Amide		3.29E-05		35%		35%
Fatty Acid Amides & Other Surfactants	Hydroxyethyl-2-Hydroxy-C16 Amide				25%		30%
Fatty Acid Amides & Other Surfactants	Lauroyl Sarcosine				20%		
Fatty Acid Amides & Other Surfactants	Lidocaine				12%		0

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Class	Compound	% Inhibition Overall TG (- ROH/RE)	Overall TG (IC 50)	% Inhibition ARAT (10µm)	% Inhibition ARAT(100µm)	% Inhibition LRAT (10µm)	% Inhibition LRAT (100µm)
Fatty Acid Amides & Other Surfactants	Linoleamide-DEA (or Linoleoyl Diethanolamide)	59%		12% +/-13	43% +/-3	11% +/-9	51% +/- 15
Fatty Acid Amides & Other Surfactants	Linoleamide-MEA (or Linoleoyl Monoethanolamide)		1.61E-05	14%	35%	20% +/- 8	35%
Fatty Acid Amides & Other Surfactans	Linoleamidopropyl Dimethylamine				69% +/-18		75% +/-4
Fatty Acid Amides & Other Surfactants	Melinamide				64% +/-15		43% +/2 21
Fatty Acid Amides & Other Surfactans	Myristoyl Sarcosine				41% +/- 14		11% +/-11
Fatty Acid Amides & Other Surfactants	Oleyl Betaine		2.80E-05		47%		
Fatty Acid Amides & Other Surfactants	Palmitamide-MEA			6%	23%	12%	33%
Fatty Acid Amides & Other Surfactants	Stearylhydroxyamide				10%		10%
Fatty Acid Amides & Other Surfactants	Utrecht-1	21%		43%	54%	51%	48% +/- 6
Fatty Acid Amides & Other Surfactants	Utrecht-2		3.47E-06	42%	83% +/-9	51%	92% +/-3
Flavanoids	Naringenin				33%		14%
Fragrances	Allyl Alpha-Ionone			16% +/-14	22% +/-23	17% +/- 10	36%/-
Fragrances	Alpha-Damascone		3.35E-04	67% +/- 27	83% +/- 12	87% +/- 6	98% +/- 1
Fragrances	Alpha=Ionone		9.27E-04		45% +/- 27		49% +/- 30
Fragrances	Alpha-Methyl Ionone				67%		77%
Fragrances	Alpha-Terpineol				26%		25%
Fragrances	Beta-Damascone			45%	84%	52%	92%
Fragrances	Brahmanol				70%		75%
Fragrances	Damascenone			23%	70%	29%	79%

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Class	Compound	% Inhibition Overall TG (- ROH/RE)	Overall TG (IC 50)	% Inhibition ARAT (10µm)	% Inhibition ARAT(100µm)	% Inhibition LRAT (10µm)	% Inhibition LRAT (100µm)
Fragrances	Delta-Damascone			58%	87%	64%	95%
Fragrances	Dihydro Alpha-Ionone				13%		18%
Fragrances	Ethyl Saffranate				51%		49%
Fragrances	Fenchyl Alcohol				12%		4%
Fragrances	Gamma-Methyl Ionone				21%		38%
Fragrances	Isobutyl Ionone				8%		45%
Fragrances	Isocyclogeraniol				18%		16%
Fragrances	Isodamascone				80%		92%
Fragrances	Lyral		1.27E-04		76%		71%
Fragrances	Santalone				23%		12%
Fragrances	Santanol				15%		43%
Fragrances	Timberol				34%		33%
Fragrances	Tonalid				50%		33%
Fragrances	Traseolide				41%		21%
Miscellaneous	Coco Trimethylammonium Cl-				27%		
Miscellaneous	Urosolic Acid		1.46E-06		21%		28%
Noncyclic Fragrances	Citral				20%		
Noncyclic Fragrances	Citronellol				30%		0
Noncyclic Fragrances	Farnesol		9.35E-05	23%+/- 18	53% +/- 18	10% +/- 7	53% +/- 19
Noncyclic Fragrances	Geraniol		7.83E-03	13%	32%		
Noncyclic Fragrances	Geranyl Geraniol			38% +/- 12	81% +/- 6	16% +/- 9	77% +/- 13
Noncyclic Fragrances	Linatool				28%		0
Noncyclic Fragrances	Nonadieneal				20%		

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Class	Compound	% Inhibition Overall TG (- ROH/RE)	Overall TG (IC 50)	% Inhibition ARAT (10µm)	% Inhibition ARAT(100µm)	% Inhibition LRAT (10µm)	% Inhibition LRAT (100µm)
Noncyclic Fragrances	Pseudoionone				12%		37%
Phospholipid	Dioctylphosphatidyl Ethanolamine			23%	50% +/- 2	0	17% +/- [redacted]
Urea	Dimethyl Imidazolidinone	22%					
Urea	Imidazolidinyl Urea	35%					

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Retinol Dehydrogenase Activators (B2)

Class	Compound	% Increase Retinol Dehydrogenase
Phospholipid	Phosphatidyl Choline	21% increase
Phospholipid	Sphingomyelin	26% increase

Retinaidehyde Reductase Inhibitors (B3)

Class	Compound	Overall TG (IC 50)	% Inhibition Retinal Reductase
Aldehyde	Vanillin	9.70E-03	6%
Fatty Acid	Arachidic Acid		20%
Fatty Acid	Arachidic Acid		49%
Fatty Acid	Linoleic Acid	1.63E-04	62% +/-2
Fatty Acid	Linolenic Acid	1.34E-04	54% +/-16
Fatty Acid	Myristic Acid	1.72E-05	26%
Miscellaneous	Amsacrine	6.26E-06	22% + /-8
Miscellaneous	Carbenoxolone	3.61E-07	26% +/-2
Miscellenous	Glycyrretinic Acid	8.64E-06	38% =/- 1
Phospholipid	Phosphatidyl ethanolamine		37%

CRABPII Antagonists (B4)

Class	Compound	Overall TG (IC 50)	% Inhibition CRABPII
Fatty Acid	Elaidic Acid	6.50E-05	>50%
Fatty Acid	Hexadecanedioic Acid	1.30E-04	>50%
Fatty Acid	12-Hydroxystearic Acid	2.91E-05	>50%
Fatty Acid	Isostearic Acid	6.88E-05	>50%
Fatty Acids	Linseed Oil		>50%

Retinoic Acid Oxidation Inhibitors (B5)

Class	Compound	Overall TG (IC 50)
Imidazole	Bifonazole	
Imidazole	Climbazole	4.47E-06
Imidazole	Clotrimazole	
Imidazole	Econazole	
Imidazole	Ketoconazole	1.85E-07
Imidazole	Miconazole	2.78E-07
Fatty Acid Amides & Other Sufactants	Lauryl Hydroxyethylimidazoline	4.67E-07
Fatty Acid Amides & Other Sufactants	Oleyl Hydroxyethylimidazoline	3.02E-05
Flavanoids	Quercetin	6.29E-05
Coumarin	Coumarin	
Quinoline	(7H-Benzimidazo[2, 1-a]Benz[de]-Isoquinolin-7-one	8.59E-07
Quinoline	Hydroxyquinoline (Carbostyril)	3.64E-04
Quinoline	Metyrapone (2-Methyl-1, 2-di-3-Pyridyl-1-Propane	

The boosters or combinations thereof inhibit transglutaminase (hereinafter "Tgase") in a transglutaminase assay described below to at least 50% at a concentration of 10mM.

TGase Assay

Invention	Compound Concentration	% Inhibition
Broad	10 mM	> 50%
Preferred	1 mM	> 50%
Most Preferred	100 μM	> 50%
Optimum	10 μM	> 50%

<u>Transglutaminase Assay and Keratinocyte Differentiation</u>

During the process of terminal differentiation in the epidermis, a 15nm thick layer of protein, known as the cornified envelope (CE) is formed on the inner surface of the cell periphery. The CE is composed of numerous distinct proteins which have been cross-linked together by the formation of N^{ϵ}-(γ-glutamyl) lysine isodipeptide bonds catalyzed by the action of at least two different transglutaminases (TGases) expressed in the epidermis. TGase I is expressed in abundance in the differentiated layers of the epidermis, especially the granular layer, but is absent in the undifferentiated basal epidermis. Thus TGase I is a useful marker of epidermal keratinocyte differentiation with high TGase I levels indicating a more differentiated state. An ELISA based TGase I assay, using a TGase I antibody, was used to assess the state of differentiation of the cultured keratinocytes in the examples that follow.

Keratinocytes (cultured as described above) were plated in 96 well plates at a density of 4,000-5,000 cells per well in 200µl media. After incubation for two to three days, or until cells are ~50% confluent, the media was changed to media containing test compounds (five replicates per test). The cells were cultured for a further 96 hours after which time the media was aspirated and the plates stored at -70°C. Plates were removed from the freezer, and the cells were washed twice with 200µl of 1x PBS. The cells were incubated for one hour at room temperature (R/T) with TBS/5% BSA (wash buffer, bovine serum albumin). Next the TGase primary antibody was added: 50µl of monoclonal anti-Tgase I Ab B.C. diluted 1:2000 in wash buffer. The primary antibody was incubated for 2 hours at 37°C and then rinsed 6x with wash buffer. Cells were then incubated with 50µl of secondary antibody (Fab fragment, peroxidase conjugated anti-mouse IgG obtaining from Amersham) diluted 1:4,000 in wash buffer for two hours at 37°C, then rinsed three times with wash buffer. Following the rinse with washing buffer, the cells were rinsed 3x with PBS. For colourimetric development, the cells were incubated with 100micro l substrate solution (4 mg o-phenylenediamine and 3.3 µl 30% H_2O_2 in 10ml 0.1M citrate buffer pH 5.0) for exactly five minutes, R/T, in darkness (under aluminum foil). The reaction was stopped by the addition of 50µl 4N H_2SO_4. The absorbance of samples was read at 492nm in a 96 well plate UV spectrophotometer. Out of the five replicates, four were treated with both antibodies, the fifth one was use as a Tgase background control. TGase levels were determined and expressed as percentage control.

Transglutaminase levels were determined and expressed in the Tables B1 through B5 above either as:

(i) % (booster + retinol inhibition / control inhibition) - % (ROH inhibition / control inhibition), which measures the added effect of booster + retinol induced TGase inhibition over retinol alone, or

(ii) as an IC50 value when the inhibitory effect of multiple booster concentrations was examined - this provides the concentration of booster which, in combination with a constant retinol concentration of 10^{-7}M, inhibits TGase by 50%.

It is the IC50 value that is used as a benchmark in the present invention.

Best Groups of Boosters for testing in Transglutaminase assay

B1 Compounds

1. Fatty Acid Amides	These are readily commercially available and have the added advantage of being surfactants and thus help generate emulsions suitable for cosmetic preparations.
2. Ceramides	These can additionally act as precursors of stratum corneum barrier ceramides.
3. Carotenoids	These can offer some UV protection and and act as natural colorants.
4. Flavonoids	Natural antioxidants.
5. Cyclic fragrances	These are readily commercially available and additionally can be used to fragrance the product.
6. Non-cyclic fragrances	These can be used to fragrance the product.
7. Phospholipid analogues	These can be utilised by skin cells to nourish the generation of barrier components.
8. Ureas	These are readily commercially available and can also act as preservatives for the product.

B2 Compounds

1. Phosphatidyl choline	Most preferred as most active activator of Retinol Dehydrogenase
2. Sphingomyelin	

B3 Compounds

Arachidonic Acid Linoleic Acid Linolenic Acid Myristic Acid	Fatty Acids which can be useful in maintaining stratum corneum barrier
Linoleic Acid Linolenic Acid	Essential Fatty Acids
Arachidonic Acid Myristic Acid	Non-essential fatty acids
Glycyrrhetinic Acid	Polycyclic triterpene carboxylic acid which is readily obtained from plant sources.
Phosphatidyl ethanolamine	Can be incorporated into cellular membranes.

B4 Compounds

Hexadecanedioic acid 12-hydroxystearic acid Isostearic acid	Saturated fatty acids.
Linseed oil Elaidic acid	Unsaturated fatty acids
Elaidic acid Isostearic acid Hexadecanedioic acid	Solid at room temperature
Linseed oil 12-hydroxystearic acid	Liquid at room temperature

B5 Compounds

Bifonazole Climbazole Clotrimazole Econazole Ketoconazole Miconazole	Antimicotics
Climbazole	Readily commercially available
Lauryl hydroxyethylimidazoline	Compounds which are readily commercially available and have the added advantage of being surfactants and thus help generate emulsions suitable for cosmetic preparations.
Quercetin	Naturally occuring flavanoid which has antioxidant properties.
Coumarin	Natural colorant
Quinolines Isoquinolines	
Metyrapone	

Retinoids

The presence of the selected compounds in the inventive product substantially improves the performance of a retinoid.

The inventive compositions include about 0.001% to about 10%, by weight of the composition of a retinoid.

The retinoid is selected from retinyl esters, retinol, retinaldehyde and retinoic acid, preferably retinol or retinyl ester. The term "retinol" includes the following isomers of retinol: all-trans-retinol, 13-cis-retinol, 11-cis-retinol, 9-cis-retinol, 3,4-didehydro-retinol, 3,4-didehydro-13-cis-retinol; 3,4-didehydro-11-cis-retinol; 3,4-didehydro-9-cis-retinol. Preferred isomers are all-trans-retinol, 13-cis-retinol, 3,4-didehydro-retinol, 9-cis-retinol. Most preferred is all-trans-retinol, due to its wide commercial availability.

Retinyl ester is an ester of retinol. The term "retinol" has been defined above. Retinyl esters suitable for use in the present invention are C_1-C_{30} esters of retinol, preferably C_2-C_{20} esters, and most preferably C_2, C_3, and C_{16} esters because they are more commonly available. Examples of retinyl esters include but are not limited to: retinyl palmitate, retinyl formate, retinyl acetate, retinyl propionate, retinyl butyrate, retinyl valerate, retinyl isovalerate, retinyl hexanoate, retinyl heptanoate, retinyl octanoate, retinyl nonanoate, retinyl decanoate, retinyl undecanoate, retinyl laurate, retinyl tridecanoate, retinyl myristate, retinyl pentadecanoate, retinyl heptadecanoate, retinyl stearate, retinyl isostearate, retinyl nonadecanoate, retinyl arachidonate, retinyl behenate, retinyl linoleate, retinyl oleate.

The preferred ester for use in the present invention is selected from retinyl palmitate, retinyl acetate and retinyl propionate, because these are the most commercially available and therefore the cheapest. Retinyl linoleate and retinyl oleate are also preferred due to their efficacy.

Retinol or retinyl ester is employed in the inventive composition in an amount of about 0.001% to about 10%, preferably in an amount of about 0.01% to about 1%, most preferably in an amount of from about 0.01% to about 0.5%.

Peroxide Value

As discussed hereinabove, retinoids are not stable in oil-in-water emulsions. The chemical stabilization of retinoids is defined by the concentration of the retinoids in their original chemical form even after a defined storage duration and temperature. Therefore, the present invention provides the dual benefit of enhancing retinoid conversion within the skin while increasing the stability of retinoids by the removal of any starting materials having a peroxide value of greater than 12 and preferably greater than 6.

The peroxide number (POV) is measured using the standard AOCS Official Method Cd 8-53, but other methods known to a person of skill in the art are also within the scope of the invention.

In the present examples, retinol stability was tested in oils with varying peroxide values to determine the effects of the peroxide value of an oil on the stability of a composition of retinol in combination with a booster. Peroxide value was calculated using the following equation 1:

Peroxide value (milliequivalents peroxide/ 1000g sample) = $\frac{(S-B) \times 1000}{\text{Mass of sample, g}}$ **[Eq. 1]**

Where B = volume of titrant, ml of blank

S = volume of titrant, ml of sample

N = Normality of sodium thiosulfate solution

Methodology

1. Weigh 5g of sample into a 250 ml flask with a glass stopper and add 30ml of the 3:2 acetic acid-chloroform solution. Swirl to dissolve the sample. Add 0.5ml of saturated KI solution.

2. Allow the solution to stand with occasional shaking for exactly 1min. and then immediately add 30ml of distilled water.

3. Titrate with 0.1N sodium thiosulfate, adding it gradually and with constant agitation. Continue the titration until the yellow iodine color has almost disappeared. Adding 0.5ml of 10% SDS, and then add about 0.5ml starch indicator solution. Continue the titration with constant agitation, especially near the end point, to liberate all of the iodine from the solvent layer. Add the thiosulfate solution dropwise until the blue color just disappears.

4. Conduct a blank determination of the reagents daily. The blank titration must not exceed 0.1ml of the 0.1N sodium thiosulfate solution.

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EXAMPLE 1

Retinol stability without boosters vs peroxide values

Raw oils/Trade Name	Chemical name	Peroxide value	Retinol half life @ 50C
Cetiol OE	Dicapryl Ether	0	72
Mineral oil	Hydrocarbon	0	58
Squalane	Hydrocarbon	0	57
Myritol PC	Propylene glycol Dicaprylate/Dicaprate	0.9	13
Myritio 318	Caprylic/Capric Triglyceride	1	21.5
Cetiol 868	Octyl Stearate	1.2	33
Protachem IPM	Isostearyl Myristate	2	39
Cetio SN	Cetearyl Isononanoate	2.1	32.1
Protachem IPP	Isostearyl Palmitate	4	34.3
Pelemol ISP	Isostearyl Palmitate	1.3	20
Dermol ISP	Isostearyl Palmitate	0	33
Jeechem ISP	Isostearyl Palmitate	2.4	20
Protachem ISP	Isostearyl Palmitate	6.8	5
Squalene	Hydrocarbon	7.3	14.8
Cetio V	Decyl Oleate	12.8	13.9
Eutanol G	Octyl Dodecanol	14.6	7.24
Borage seed oil	Vegetable oil	76.8	3.3
Corn Oil	Vegetable oil	168	5.6

EXAMPLE 2

Retinoil stability with boosters vs POV (t1/2 was predicted based on 2 ~ 3 weeks stability data)

Oil+ LAMEA (B1)			retinol% remain	predicted
example #	Oil	POV	2wks @ 50 C	t1/2, day
1	mineral oil	0	90.8	57
2	Dermal ISP	0.2	86	57
3	Caprylic/capric Triglyceride	0.4	78	55
4	Pelemol I-1816(ISP)	1.3	81.7	55
5	Cetio SN	2.1	63	26.3
6	Protachem IPP	4	63	17.6
7	Protachem ISP	6.9	52.2	15.7
8	Borage seed oil	14.2	46	13.3
9	Borage seed oil	76.8	27.4	6.4

EXAMPLE 3

Oil+ linoleic acid (B3)			retinol% remain	retinol% remain	predicted
example #	Oil	POV	1wks @ 50 C	2wk @50 C	t1/2, day
10	Squalane	0	91.3	88	53
11	Pelemol I-1816	1.3	88.2	72.9	32
12	Protachem ISP	6.9	52.4	30.8	8.8
13	Eutanol G	11.7	41.3	14.4	5.1
14	Borage seed oil	76.8	33.9	18	5

EXAMPLE 4

Oil+ linseed oil (B4)			retinol% remain	retinol% remain	predicted
xample #	Oil	POV	1wks @ 50 C	2wk @50 C	t1/2, day
15	mineral oil	0	99	88	77
16	Caprylic/capric Triglyceride	0.4	91.9	75	32.8
17	Protachem IPP	4	54.9	29.2	21
18	Eutanol G	11.7	60.6	33.9	9.1
19	Borage seed oil	76.8	26	18	5.1

EXAMPLE 5

Oil+ climbazole (B5)			retinol% remain	retinol% remain	predicted
example #	Oil	POV	1wks @ 50 C	2wk @50 C	t1/2, day
15	mineral oil	0	80.6	72.1	29
16	Caprylic/capric Triglyceride	0.4	91.9	75	32.8
17	Pelemol I-1816 (ISP)	1.3	68.2	56.2	18
18	Protachem IPP	4	54.9	29.2	7.5
19	Borage seed oil	76.8	26	18	5.5

EXAMPLE 6

mixed Oil+ phosphatidyl choline (B2)			retinol% remain	retinol% remain	predicted
example #	Oil	POV	1wks @ 50 C	3wk @50 C	t1/2, day
20	Cetiol OE	0	98	82.4	77
21	Cetiol OE+ Borage seed oil(97/3)		96.3	74.6	58.7
22	Cetiol OE+ Borade seed oil(93/7)		95	63.5	37.9
23	Cetiol OE+ Borage seed oil(85/15)		83	44.7	20
24	Cetiol OE+ Borage seed oil(70/30)		69.7	25.1	11.2
25	Borage seed oil	76.8	26		5

* Average calculated from individual POV values.

Cosmetically Acceptable Vehicle

The composition according to the invention also comprises a cosmetically acceptable vehicle to act as a dilutant, dispersant or carrier for the active components in the composition, so as to facilitate their distribution when the composition is applied to the skin.

Vehicles other than or in addition to water can include liquid or solid emollients, solvents, humectants, thickeners and powders. An especially preferred nonaqueous carrier is a polydimethyl siloxane and/or a polydimethyl phenyl siloxane. Silicones of this invention may be those with viscosities ranging anywhere from about 10 to 10,000,000 centistokes at 25°C. Especially desirable are mixtures of low and high viscosity silicones. These silicones are available from the General Electric Company under trademarks Vicasil, SE and SF and from the Dow Corning Company under the 200 and 550 Series. Amounts of silicone which can be utilized in the compositions of this invention range anywhere from 5 to 95%, preferably from 25 to 90% by weight of the composition.

Optional Skin Benefit Materials and Cosmetic Adjuncts

An oil or oily material may be present, together with an emulsifier to provide either a water-in-oil emulsion or an oil-in-water emulsion, depending largely on the average hydrophilic-lipophilic balance (HLB) of the emulsifier employed.

Various types of active ingredients may be present in cosmetic compositions of the present invention. Actives are defined as skin or hair benefit agents other than

emollients and other than ingredients that merely improve the physical characteristics of the composition. Although not limited to this category, general examples include sunscreens, skin lightening agents, tanning agents.

Sunscreens include those materials commonly employed to block ultraviolet light. Illustrative compounds are the derivatives of PABA, cinnamate and salicylate. For example, octyl methoxycinnamate and 2-hydroxy-4-methoxy benzophenone (also known as oxybenzone) can be used. Octyl methoxycinnamate and 2-hydroxy-4-methoxy benzophenone are commercially available under the trademarks, Parsol MCX and Benzophenone-3, respectively.

The exact amount of sunscreen employed in the emulsions can vary depending upon the degree of protection desired from the sun's UV radiation.

Another preferred optional ingredient is selected from essential fatty acids (EFAs), i.e., those fatty acids which are essential for the plasma membrane formation of all cells. In keratinocytes EFA deficiency makes cells hyperproliferative. Supplementation of EFA corrects this. EFAs also enhance lipid biosynthesis of epidermis and provide lipids for the barrier formation of the epidermis. The essential fatty acids are preferably chosen from linoleic acid, ϒ-linolenic acid, homo-ϒ-linolenic acid, columbinic acid, eicosa-(n-6,9,13)-trienoic acid, arachidonic acid, ϒ-linolenic acid, timnodonic acid, hexaenoic acid and mixtures thereof.

Emollients are often incorporated into cosmetic compositions of the present invention. Levels of such emollients may range from about 0.5% to about 50%, preferably between about 5% and 30% by weight of the total composition. Emollients

may be classified under such general chemical categories as esters, fatty acids and alcohols, polyols and hydrocarbons.

Esters may be mono- or di-esters. Acceptable examples of fatty di-esters include dibutyl adipate, diethyl sebacate, diisopropyl dimerate, and dioctyl succinate. Acceptable branched chain fatty esters include 2-ethyl-hexyl myristate, isopropyl stearate and isostearyl palmitate. Acceptable tribasic acid esters include triisopropyl trilinoleate and trilauryl citrate. Acceptable straight chain fatty esters include lauryl palmitate, myristyl lactate, oleyl eurcate and stearyl oleate. Preferred esters include coco-caprylate/caprate (a blend of coco-caprylate and coco-caprate), propylene glycol myristyl ether acetate, diisopropyl adipate and cetyl octanoate.

Suitable fatty alcohols and acids include those compounds having from 10 to 20 carbon atoms. Especially preferred are such compounds such as cetyl, myristyl, palmitic and stearyl alcohols and acids.

Among the polyols which may serve as emollients are linear and branched chain alkyl polyhydroxyl compounds. For example, propylene glycol, sorbitol and glycerin are preferred. Also useful may be polymeric polyols such as polypropylene glycol and polyethylene glycol. Butylene and propylene glycol are also especially preferred as penetration enhancers.

Exemplary hydrocarbons which may serve as emollients are those having hydrocarbon chains anywhere from 12 to 30 carbon atoms. Specific examples include mineral oil, petroleum jelly, squalene and isoparaffins.

Another category of functional ingredients within the cosmetic compositions of the present invention are thickeners. A thickener will usually be present in amounts anywhere from 0.1 to 20% by weight, preferably about 0.5% to 10% by weight of the composition. Exemplary thickeners are cross-linked polyacrylate materials available under the trademark Carbopol from the B.F. Goodrich Company. Gums may be employed such as xanthan, carrageenan, gelatin, karaya, pectin and locust beans gum. Under certain circumstances the thickening function may be accomplished by a material also serving as a silicone or emollient. For instance, silicone gums in excess of 10 centistokes and esters such as glycerol stearate have dual functionality.

Powders may be incorporated into the cosmetic composition of the invention. These powders include chalk, talc, Fullers earth, kaolin, starch, smectite clays, chemically modified magnesium aluminum silicate, organically modified montmorillonite clay, hydrated aluminum silicate, fumed silica, aluminum starch octenyl succinate and mixtures thereof.

Other adjunct minor components may also be incorporated into the cosmetic compositions. These ingredients may include coloring agents, opacifiers and perfumes. Amounts of these materials may range anywhere from 0.001% up to 20% by weight of the composition.

Use of the Composition

The composition according to the invention is intended primarily as a product for topical application to human skin, especially as an agent for conditioning and smoothening the skin, and preventing or reducing the appearance of wrinkled or aged skin.

In use, a small quantity of the composition, for example from 1 to 5ml, is applied to exposed areas of the skin, from a suitable container or applicator and, if necessary, it is then spread over and/or rubbed into the skin using the hand or fingers or a suitable device.

Product Form and Packaging

The topical skin treatment composition of the invention can be formulated as a lotion, a fluid cream, a cream or a gel. The composition can be packaged in a suitable container to suit its viscosity and intended use by the consumer. For example, a lotion or fluid cream can be packaged in a bottle or a roll-ball applicator, or a capsule, or a propellant-driven aerosol device or a container fitted with a pump suitable for finger operation. When the composition is a cream, it can simply be stored in a non-deformable bottle or squeeze container, such as a tube or a lidded jar.

The invention accordingly also provides a closed container containing a cosmetically acceptable composition as herein defined.

The following examples show the synergistic combination of retinol and boosters.

EXAMPLE 7

To establish whether synergistic inhibition of transglutaminase expression occurred by combinations of B1 and B5 active compounds with retinol, it is essential to determine the dose response profiles (including IC50 values) of the active compounds when tested individually in the presence of retinol. This data was used to determine an appropriate sub-maximal inhibitory concentration of each

active compound, to make it possible to identify synergistic effects of mixtures of the active compounds in the presence of retinol. In order to demonstrate synergy of two compounds, it is essential to select concentrations to test that are at most IC20, in other words a compound concentration that individually boosts the retinol inhibition of transglutaminase expression by 20%. Two such compounds should have an additive inhibition of 40%. Using this strategy to determine concentration leaves a window of 40-100% for further transglutaminase inhibition for detecting synergy of the two compounds under examination. A more challenging concentration criteria would be selecting concentrations of compounds which alone showed no boosted retinol inhibition of transglutaminase. In this study however we chose an even more challenging criteria. We selected concentrations of compounds that were 10 fold and 100 fold lower than the minimally effective transglutaminase inhibiting concentration. Identification of synergistic combinations using such very low concentrations would mean that the most effective synergistic combinations were identified.

The data in the following table represents the concentrations of compound that are 2 logs lower than the minimally inhibitory compound concentration. These were the concentrations used in the B1/B5 combination studies.

Compound	Concentration
B1 Compounds	
Linoleoyl monoethanolamide	1.00E-06
Palmitamide monoethanolamide	1.00E-06
Farnesol	3.16E-06
Hexyl sphingosine	1.00E-06
Utrecht-2	3.16E-08
Oleoyl betaine	3.16E-07
Oleoyl hydroxyethylimidazoline	1.00E-08
Cocoyl hydroxyethylimidazoline	1.00E-09
Ursolic acid	1.00E-08
Alpha-ionone	3.16E-05
B5 Compounds	
Ketoconazole	1.00E-09
Miconazole	3.16E-09
Climbazole	1.00E-08
Amino benzotriazole	1.00E-06
3,4-dihydroquinoline	1.00E-06
2-hydroxyquinoline	3.16E-06

To investigate synergistic inhibition of transglutaminase expression by combinations of B1 and B5 active compounds with retinol, selected combinations of compounds were tested at concentrations given in the above table. The following data was obtained:

Combination	B1 Compound	B5 Compound	Mean % control Tgase
B1 / B5	*Farnesol*	*Ketoconazole*	*84%*
B1 / B5	*Hexanoyl sphingosine*	*Miconazole*	*68%*
B1 / B5	*Hexanoyl sphingosine*	*Ketoconazole*	*64%*
B1 / B5	*Hexanoyl sphingosine*	*3,4-dihydroquinoline*	*89%*
B1 / B5	*Hexanoyl sphingosine*	*Aminobenzotriazole*	*81%*
B1 / B5	*Hexanoyl sphingosine*	*Climbazole*	*63%*
B1 / B5	*Oleoyl betaine*	*Ketoconazole*	*81%*
B1 / B5	*Oleoyl hydroxyethylimidazoline*	*Climbazole*	*52%*
B1 / B5	*Cocoyl hydroxyethylimidazoline*	*Climbazole*	*71%*
B1 / B5	*Ursolic acid*	*2-hydroxyquinoline*	*74%*
B1 / B5	*Alpha-ionone*	*Miconazole*	*84%*
B1 / B5	*Alpha-ionone*	*Ketoconazole*	*82%*
B1 / B5	*Alpha-ionone*	*2-hydroxyquinoline*	*76%*
B1 / B5	*Utrecht-2*	*aminobenzotriazole*	*82%*
B1 / B5	Linoleoyl monoethanolamide	Ketoconazole	93%
B1 / B5	Linoleoyl monoethanolamide	Climbazole	94%
B1 / B5	Naringenin	Ketoconazole	100%
B1 / B5	Quercetin	Climbazole	92%
B1 / B5	Castor Oil monoethanolamide	Climbazole	98%
B1 / B5	Castor Oil monoethanolamide	Clotrimazole	100%

The efficacy of the B1/B5 combinations splits into two classes – particularly effective combinations (*italicized* in the above table, i.e., the top 14 combinations or

rows) and barely effective combinations (not italicized, i.e., the bottom 6 combinations or rows). It was unexpected that certain B1/B5 combinations performed better than other combinations. Those combinations which were barely effective were (i) fatty acid amides + azoles (ii) hydroxy fatty acid amides + azoles and (iii) naringenin/quercetin + azoles. The effective combinations contained B1 boosters combined with B5 boosters from the following classes: fatty hydroxyethyl imidazoline surfactants, cyclic aliphatic unsaturated compounds, polycyclic triterpenes, n-substituted fatty acid amides.

While the present invention has been described herein with some specificity, and with reference to certain preferred embodiments thereof, those of ordinary skill in the art will recognize numerous variations, modifications and substitutions of that which has been described which can be made, and which are within the scope and spirit of the invention. It is intended that all of these modifications and variations be within the scope of the present invention as described and claimed herein, and that the invention be limited only by the scope of the claims which follow, and that such claims be interpreted as broadly as is reasonable. Throughout this application, various publications and books have been cited. The entireties of each of these publications and books are hereby incorporated by reference herein.